Name _____

Protein Synthesis Simulation

Deoxyribonucleic acid (DNA) carries inherited genetic information in the coded sequence of its nitrogenous bases. For this code to be changed into the metabolic processes of a living organism, the DNA sequence is ***transcribed*** to the nucleotide sequence of a messenger ribonucleic acid (mRNA) molecule. Three mRNA nucleotides (a codon) code for one specific amino acid. The sequence of mRNA codons is ***translated*** into chains of the 20 different amino acids at the ribosomes by transfer RNA (tRNA). Each anticodon loop made of three tRNA nucleotides attaches to a specific amino acid. These amino acid chains constitute proteins that catalyze the biochemical reactions of living organisms.

Assembly

Use the key in the table below to assist you in building a protein.

Kit Component	***Part of DNA molecule***	***Quantity Needed***
Pink beads	Ribose sugar	24
Red beads	Phosphate group	24
Orange beads	Adenine (A)	6
Green beads	Guanine (G)	6
Blue beads	Cytosine (C)	6
Purple beads	Uracil (U)	6
White Oval beads	Transfer RNA (tRNA)	7
White Twist beads	Amino Acid	7

To prepare your mRNA molecule for translation:

1. Position your mRNA molecule horizontally on your desk with the 5' end (phosphate hole) to the left and the 3' end (sugar peg) to the right.
2. Align all of the nitrogenous bases along the upper edge of the mRNA strand.
3. Write the letter representing each mRNA nitrogenous base in order in the space provided.
4. Record these bases as codons (organized into groups of three) in the space provided.
5. Write the complementary tRNA anticodons in the space provided.
6. Determine the amino acid coded for by each **mRNA codon** using your decoder.
    - AUG is a START codon which codes for fMet
    - UAG, UAA, and UGA are STOP codons that do NOT actually code for amino acids

mRNA bases __

mRNA codons _____, _____, _____, _____, _____, _____, _____, _____

tRNA anticodons _____, _____, _____, _____, _____, _____, _____, _____

Amino Acids _____, _____, _____, _____, _____, _____, _____, _____

Each amino acid is carried to the site by a specific tRNA molecule. To "charge" the tRNA as shown in Figure 1, follow the directions below:

7. Using the **tRNA anticodons** and amino acids you just recorded, connect the proper amino acid bead to its tRNA anticodon bead.
8. Orient the white beads so that the peg at the bottom of the twisted amino acid bead pops into the hole at the top of the oval tRNA bead (see Figure 1).

To translate your mRNA sequence into a protein, follow the directions below:

9. With the mRNA strand positioned 5' to 3' in front of you, bring the yellow ribosome to the mRNA strand.
10. Slide the ribosome under the mRNA so that the first codon lies in the P site and the second codon in the A site (see Figure 2).
11. Find the tRNA anticodon that is complementary to the first mRNA codon and bring it (with its attached amino acid) to the empty P site of the ribosome.
    - This special initiator complex, with fMet as its amino acid, is the only tRNA-amino acid complex that can enter the empty P site and begin a protein.
12. Place the peg of the rTNA bead into the opening of the central nucleotide of the codon, which in this case is uracil (see Figure 3).
    - In reality, the tRNA anticodon bonds with all three nucleotides of the codon, but due to the limitations in the structure of the beads, our tRNA molecule will temporarily attach to the central nucleotide of the codon.

13. Next bring the proper tRNA-amino acid complex to pair with the exposed codon in the A site and attach it to the central nucleotide (see Figure 4).
    - Both P and A sites of the ribosome should now be occupied. At this time, a bond forms between the amino acid in the P site and the amino acid in the A site.
14. Detach the amino acid in the P site from its tRNA and place the peg into the opening of the amino acid in the A site (see Figure 5).

15. Move the ribosome down the mRNA a distance of one codon (three nucleotides) so that the uncharged tRNA no longer occupies the P site.
16. Remove the uncharged tRNA from the mRNA chain and set it aside.
17. The second codon with two attached amino acids should now be in the P site, leaving the third codon exposed in the vacant A site (see Figure 6).

18. Bring in the correct tRNA-amino acid complex coinciding with the exposed codon now in the A site and attach it as before to the central nucleotide.
19. Transfer the small protein chain (two amino acids) in the P site to the A site by attaching the peg of the protein chain to the opening of the amino acid in the A site.
    - This leaves an uncharged tRNA in the P site.
20. Once again, move the ribosome down the mRNA a distance of one codon and remove this uncharged tRNA from the mRNA chain.
    - The incomplete chain of amino acids now lies in the P site.
21. Bring in the next tRNA-amino acid complex, transfer the chain of amino acids from the P to the A site, and move the ribosome down the mRNA one codon at a time until the last codon is reached. Be sure to remove the uncharged tRNA from the mRNA chain as it leaves the P site each time.

The completed protein chain of seven amino acids should be attached to the mRNA in the P site and the final codon exposed in the vacant A site. The codons UAA, UAG, and UGA all specify for the termination of the protein chain and its subsequent release form the ribosome. No tRNAs possess an anticodon for reading the termination codons. A release factor binds to the A site from the P site. Follow the directions below to release your amino acid chain.

22. Detach the completed protein from the tRNA in the P site and transfer it to the A site.
23. Release the completed protein.
24. Remove the remaining uncharged tRNA in the P site from the mRNA.
25. Detach the ribosome from the mRNA strand.

Record the abbreviations for the amino acids of your completed protein in order.

_____	_____	_____	_____	_____	_____	_____
1	2	3	4	5	6	7

Finally, review the process used to create your protein by answering the following questions. (See the bolded words on the first page for clues.)

1. The process whereby mRNA is manufactured from DNA is called _____.

2. The assembly of an amino acid chain according the sequence of base triplets in a molecule of mRNA is called _____.

3. A continuous triplet of mRNA that specifies a particular amino acid is called a/an _____.

4. A three-base sequence on one loop of a tRNA molecule (that is complementary to the mRNA triplet), which joins the appropriate amino acid and its mRNA is called a/an _____.